PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:	WO 94/11116
B05C 11/02	A1	(43) International Publication Date:	26 May 1994 (26.05.94)

(21) International Application Number: PCT/FI93/00453

(22) International Filing Date: 5 November 1993 (05.11.93)

(30) Priority data:

925045	6 November 1992 (06.11.92)	FI
934890	5 November 1993 (05.11.93)	FI

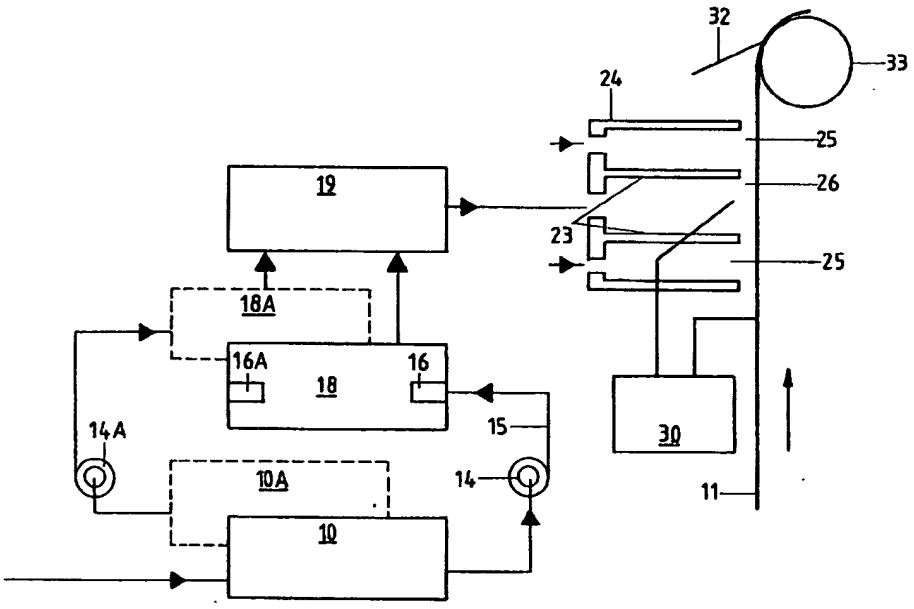
(71)(72) Applicants and Inventors: SUNDHOLM, Patrick [FI/FI]; Smedsintie 7 A, FIN-02700 Kauniainen (FI). DONNELLY, Robert [US/NZ]; 32 MacMillan Avenue, Christchurch (NZ). KANGAS, Martti [US/US]; P.O. Box 2470, Decatur, GA 30031 (US).

(74) Agent: KEIJO HEINONEN OY; Fredrikinkatu 61 A, P.O. Box 671, FIN-00101 Helsinki (FI).

(81) Designated States: AU, BR, CA, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
In English translation (filed in Finnish).

(54) Title: METHOD AND APPARATUS FOR COATING PAPER OR THE LIKE



(57) Abstract

An application method and apparatus making able to apply a paper web or like in whatever stage of the process from the first dewatering step until the final drying step. The process comprises forming a fog from the coating slurry and directing the fog into a nozzle (24), which is not in physical contact with the web (11). The coating layer is smoothened after the application, using e.g. a doctor blade (32), or in surface sizing the web is led between two rollers.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan.	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

METHOD AND APPARATUS FOR COATING PAPER OR THE LIKE.

It is well known that paper, paper board, or other materials of this kind can be applied by various substances to change the surface texture, colour or the like. These coatings often contain clay (kaolin) or other relatively heavy materials as talc or chalk and binders as latex or modified starch, for filling up the somewhat porous surface of the paper or paper board to produce a smooth surface.

The coatings improve the quality of the paper, e.g. the shine, the brightness, the transparency, the smoothness, the surface strength, the absorption characteristics. One or more coating layers are applied onto the surface of the uncoated paper to fill up roughness of the paper surface and thus to render the said surface even, to give a more smooth and microporous surface. Depending on the quality of the paper, the paper web is applied with different amounts of coating in one or more steps. An appropriate surplus of wet coating is applied onto the paper web using a dosing device, through which the paper is conveyed. To give an even thickness to the coating on the surface of the paper web, a doctor or a so called doctor blade or knife, which extends over the whole width of the paper web, is installed spaced from the dosing device. Until 90 % of the coating is scraped off. This wears down the blade and the maintenance, e.g. the changing of the doctor, is considerably time consuming.

As a coating, e.g. only starch, can be employed, as is the case in manufacturing of copying or letter paper, then this is called surface sizing. In surface sizing after the surface coating, the paper web is led through a nip formed between two rolls. In among others the publications Tappi J. August 1992 pp 79-84 (Jarkko Tehomaa et al.: A comparison of different high speed surface sizing techniques for fine paper) and Tappi J. Dec. 1990 pp 69-75 (Charles P.

Klass: Trends and developments in size press technology), examples on surface sizing are given.

It is well known in the field, that paper is usually manufactured in a continuous process, where the web first has a very high water content, whereafter the water content is gradually decreased, until essentially all water has been removed from the web. Because of the nature of the process and apparatus for applying the coatings, the choice of the process step, where the coatings are to be added is very limited. Especially clay or the like is applied on the surface and scraped to the desired thickness using a doctor blade or a corresponding mechanical device, e.g. an air knife. Very many different types of doctors are known and even if in the present text for simplicity reference is always made to doctors, it is emphasized that the invention is not limited to the use of only doctors but that it can be applied to all such devices that are extending over essentially the whole width of the paper web and which are used after the paper coating has been applied.

Some efforts have been made to spray the coatings on paper like substrates, but these spray techniques have never led to successful application. In FI application 911390 a process and apparatus for coating a web is disclosed without mechanical contact, in which process the web is conveyed continuously along a path, the coating material is formed on the web in a slurry containing a solid particulate coating, the slurry is broken up into small particles for producing a fog of coating material to be applied onto the web, said fog having solid particulate material as a gas suspension, a sufficient gas stream is produced to maintain the solid material in particle form in suspension, and the fog containing the solid particulate material is directed towards the web for adherence the solid particulate material onto the web.

For many years higher paper web speeds have been desired for to increase production rates. Presently paper web speeds between 1000-1500 m/min are common and in the future even greater speeds will be possible.

For resolving the problems mentioned above, the present invention shows the characteristics disclosed in the characterizing part of claim 1.

The objective of this invention is generally coating or sizing paper webs or like and concerns especially a process and an apparatus for coating a web. Another objective of the invention is to obtain a smooth paper surface. Yet another objective is to obtain a better paper quality, so that the paper can be coated with a greater amount of coating and/or the formerly attained coating amounts can be obtained using fewer coating steps. The pressure of the mechanical doctor can be decreased. The doctor blade pressure needed is considerably smaller than in existing devices in industry. The wetting of the paper web can be decreased. The productional efficiency of the surface sizing is increased.

This invention comprises making a slurry to be used as the coating material mixture or sizing mixture and producing a fog. The coating material mixture or sizing mixture, before adherence it onto the paper, is broken up into a fog using a gas under pressure. After spraying, the coated or surface sized web is treated by a doctor or it is pressed between two rotating rolls or like, to smooth the coating or sizing layer and to making possible the chemicals, the coating and/or the sizing to penetrate into the paper.

In different embodiments the fog can be mixed with such fogs that contain other coatings if desired; then the final coatings are directed towards the web. In one embodiment the fog and the web can contain static charges, which help

the fog to adhere and to stay on the web, even if, the process is successful even without using static charges. Furthermore, the fog can be generated in many different ways e.g. by using normal spray nozzles. In the invention ultra sonic energy and ultra sonic nozzles well known in the field can be employed.

These and other features and advantages of the invention are disclosed in the following description, when read together with the therewith attached drawing, where:

Figure 1 presents a cross sectional view of a schematic drawing of a coating nozzle.

Figure 2 presents a schematic flow diagram showing the dosing device of the invention for coating paper.

Figure 3 presents different alternatives for smoothing the paper web, which has been coated using a paper machine or a separate coating machine.

Figures 4 and 5 present structures of nozzles.

Referring now to the drawing and to the embodiments of this invention disclosed here, it should be mentioned, that many of the features disclosed in FI application 911390 can be incorporated to the apparatus.

In Figure 1 an example of an application nozzle 24 is given, where air channels 25 are disposed around the capillary tube 26 of the slurry channel. The coating slurry is brought in the form of a slurry to the slurry channel 26. The slurry channel and the air channels narrow off towards the outlet. The air from the air channels is directed to break up the slurry into a fog and to further break up it, if the slurry already has been reduced into a fog in an earlier stage. The coating mixture hits the paper web and

adheres to it. The distance of the application nozzle from the paper can be adjusted according to the need. The slurry is conducted to the slurry channel in form of a slurry if it is dilute wherein it is broken up just a moment before it hits the paper. The outlet end of the nozzle has e.g. a diameter of 1-5 mm or 3-5 mm. The nozzles can be aligned in a row, over the width of the web to be coated, either in the same or a different plane, and the air and slurry channels are arranged concentrically so that the fog broken up through them is applied evenly on the surface of the paper. The nozzle according to Figure 1 can be formed into one uniform nozzle where the outlet of the slurry channel is formed into a slot extending over the whole width of the web and its dimensions e.g. 2-5 mm x 6 m. The air channels are then arranged on the both sides of the slot and spaced apart from each others. In the more advantageous situation a dosing device of the usual type can be replaced only by the nozzle 24 with the air and slurry channels. Figures 4 and 5 show further different embodiments of the nozzles.

Furthermore, the amount of the coating applied can be easily adjusted. The penetration of and the adhered coating can be optimized by defining for each spray a suitable hit angle of the spray. The optimal value of the angle is not critical in all circumstances as the excess coating can always be collected or scraped off, but then the paper strain is added. A suitable pressure for the breaking up/-accelerating gas (air) is 0,5-25 bar. A great pressure usually leads to a greater coating mixture velocity after the nozzle and this results that the coating penetrates deeper in the paper pores. The deepest penetration in the paper is obtained when the nozzles are slightly inclined against the direction of the incoming paper web. The optimal angle of the nozzles against the paper web line depends, as was stated, on:

- the velocity of the paper web
- the average droplet velocity of the broken up coating fog

produced by the nozzle (the velocity of the breaking up air, that breaks up drops and gives them velocity, which at the point of discharge can approach the sonic speed depending on the structure of the opening or/and the slot/slots),
- the distance of the nozzle from the web (0,02-2 m)
- the diameter (0,02-10 mm) of the application opening or the width of the coating slot of the nozzle and the starting velocity given to the coating/sizing by a pump or an inner ejector.

In displacing the fog the pressure can be adjusted as needed to obtain an acceptable coating. The apparatus is naturally provided with an appropriate air-conditioning system, which is not disclosed here.

After application the web is conveyed through the doctor 32. The doctor blade is pressed against the roll 33. It should be mentioned, that the knife pressure can be considerably lower than in coventional application techniques, as the amounts of the fed coating can be easily dosed, wherein an excess amount of coating can be avoided. The main function of the doctor can be to meter or level. In a pilot-plant test a coating amount of 25 g/m^2 was obtained in one coating step, whereas in conventional processes a coating amount of 15-16 g/m^2 in one step was obtained on one side. A mechanical (or air) knife can function as brushing or removing slurry paste. The choice of the main function, between brushing or removing the paste, depends on the speed of the web to be coated, the type of paste and on the desired amounts of coating. A high blade pressure leads to a scraping phenomena and to an unwanted straining of the paper in removing the paste from the paper web. It is to be noted, that when paper is sized with a starch solution, the characteristics of this solution are totally different from the usual mineral coating or slurry.

In the process according to the invention the surface si-

zing and application speeds can be increased and it is estimated that the velocity of 2000 m/min can be reached, which was the maximum speed of the test machine in one of the pilot-plant tests. Thus, it can be said, that the limit speed of the application can be said to be dependant on the mechanically reachable speed of the machine as on the application process itself. The application can be performed in one or more steps. The coated paper can be smoothened, doctored, instead of using a doctor or in combination with a doctor e.g. by passing it between two rolls. An air knife or air brush or any combination of these can also be employed.

Upon visual inspection using ultra violet light it was noticed, that, for both gravure paper and off set paper in experimental application tests using paper speeds from 1000 to 1800 m/min, the process according to the invention gave a smoother surface to the paper than non-using doctoring and spraying.

In the embodiment according to Figure 2 the slurry is removed from the tank 10 by a pump 14, the outlet of which is connected to a line 15 for feeding a nozzle 16. The nozzle 16 breaks up the slurry from the tank 10 so that the slurry becomes a spray having a very small particle size or a fog size. In this application the material will be referred to as a fog and it should be understood that this term includes range of forms from a very small particle aerosol to a relatively small particle spray.

The nozzle 16 may comprise many specific pieces of hardware. It is possible, that by using the pump 14 having sufficient pressure, the nozzle 16 may actually be a fluid type nozzle, wherein the nozzle will break up the fluid that flows therethrough to produce a fine particle spray, or a nozzle, where a gas under pressure breaks up the liquid and mixes therewith to form a fog. It is also possible to use

an ultrasonic nozzle, usually of the type disclosed in the US patent 4352459 of Berger et al. The ultrasonic nozzles are well known in the art, and those skilled in the art will understand without further explanation.

One further embodiment that the nozzle 16 may take, is a transducer located at the bottom of the tank 18. It will be noted, that the tank 18 is described as having some slurry in the bottom of it, and the fog in the upper part of the tank 18. By placing the transducer at the bottom of the tank 18, ultra sonic energy can break up the slurry into fine particles to produce the desired fog above the liquid, and the additional fog being generated is removed for use.

It will be noted that the fog from the tank 18 is directed to a mixing chamber 19, and further that there is a second tank 18A, which also has its output directed to the mixing chamber 19. If desired, one might have two or more tanks such as the tanks 18 and 18A, each of the tanks 18 and 18A containing a different slurry and different fog so that two or more materials can be coated on a web 11 simultaneously.

Another means for providing two different materials for coating the web 11 is to provide two or more of the tanks as the tank 10. In the Fig. 2 a second tank 10A is disclosed, and a pump 14A moves material from the tank 10A and feeds it through the line 15A to a nozzle 16A in the tank 18. Thus, two different types of fogs are generated within the tank 18 by the nozzles 16 and 16A. The mixed fogs will then be either directed to a mixing tank 19 or directly to the application nozzle 24.

This invention provides also an injection device 23, which injects air or other gas to the stream of fog. The injection means 23 are placed adjacent to the walls of the application nozzle 24 and in this position a curtain of gas is placed along the walls, to prevent the attachment of the

droplets on the walls.

To assist in causing the fog to attach to the substrate 11, it is contemplated that a static electric charge will be utilized on the fog and on the web 11. Those skilled in the art will readily understand that the web 11 can be charged, and that the fog can be charged by means of grating or the like. For purposes of illustration a charge generator is indicated at 30, there being only one charge generator shown. Nevertheless, it will be understood, that one charge (e.g. a negative) can be generated on the substrate 11, while the opposite charge (e.g. a positive) can be placed on the fog. These opposite charges will cause the fog to be attracted to the substrate 11 and stick thereto.

Different alternatives for smoothing (doctoring) of the paper using a paper machine or separate application machines are disclosed in Figure 3. Figure 3a discloses an embodiment of a doctor 32, an air brush or their combination. Figure 3b discloses a pair of rollers 34, used for a surface sized paper web, through which rollers the paper web is conducted. An air knife presented by a broken line can be added after the roller pair, if desired. The paper web can move upwards or in a horizontal direction. A small amount of pigment can be added to the starch, and this is called pigmentation.

An important feature of this invention is the application of the fog containing coating material to a web 11 at low pressure and without mechanical manipulation or the like. This allows the system of the invention to be utilized for coating paper anywhere along the paper production line, from the first de-watering stage until the paper has been completely dried. If desired, the paper can be manufactured and rolled up, and the rolls can be transported to another location, unrolled and then coated using the system according to the invention.

It will therefore be seen that this invention provides an extremely simple method and apparatus for coating a paper web or like. Since the slurry to be coated on the web is transformed into a fog and the fog is applied at very low pressure, it will be understood, that the web will never be harmed, even when the web contains much water. Furthermore, it will be understood that any conventional drying technique is appropriate so that infrared lamps or the like can be utilized to dry the coating on paper or board.

The extra coating material that is accumulated to the doctor blade, can be collected by usual means for later exploitation.

The invention has been described above referring to only one of its preferable embodiments, but it is clear, that the invention can be realized in other possible ways within the scope of the patent claims without changing the scope of the present invention. It is possible to use different coating techniques or machines. A remarkable improvement has been done in view of known art.

CLAIMS

1. A process for coating a paper web, a paper board web or like, said process comprises the steps of applying a coating mixture layer on the paper web (11), smoothening or doctoring the paper (11) thereafter using a smoothening device (32,34), characterized in, that said process has steps of breaking up a coating mixture into a fog, applying said fog at a pressure through a nozzle (24) onto the paper web (11), and smoothening the paper web (11) coated by the fog using a smoothening device (32,34).

2. A process according to the claim 1, characterized in, that the paper web (11) when coated by a starch fog is pressed using two rolls (34) placed on both sides of the web, e.g. when employing a surface sizing unit.

3. A process according to the claim 1, characterized in, that the web (11) is smoothened using a doctor blade (32) known in the art, whereas, however, the blade pressure is lower than in the conventional smoothening process, or that the web is smoothened using an air knife or an air brush.

4. A process according to any of the above claims, characterized in, that the web (11) is smoothened using a combination of an air knife and/or an air brush and a doctor or rollers or a combination of some of these.

5. A process for coating a paper web, a board web or a like paper web or like, where the web (11) is moving continuously along a path, providing a slurry containing the material to be coated on said web, breaking up the slurry into small particles, producing a fog containing the material to be coated, directing the fog against the web (11) for adherence to the web (11), adjusting the application nozzle close to the web (11) when directing the fog, producing a positive force to force the fog towards the web

(11), and further producing several slurries for coating the web (11), and producing a fog from each slurry, mixing all the fogs created and directing the resulting mixture of the fogs to the application nozzle (24), characterized in, that breaking up the slurries into a fog, feeding the fog onto the paper web (11), and smoothening after the application the web coated by the fog by smoothening means (32,34).

6. An apparatus for coating a continuously moving paper web or like (11), which apparatus comprises a dosing device for the coating, a doctor blade or like for the coated web, characterized in, that the apparatus includes an application nozzle (24) on a distance from the web, for feeding the slurry or the fog on the web, so that the slurry is broken up into a fog by gas under pressure before it adheres to the web, and a smoothening device (32,34) for the coated web (11).

7. An apparatus for coating a continuously moving paper web or like (11), which apparatus comprises means for producing the slurry containing a solid material, to be coated on the web (11), means (16) for breaking up the slurry in a gas under pressure to fine particles for producing a fog containing the solid material to be coated on the web (11), application means (24) for coating the fog on the web (11), the application means (24) being situated close to the web (11) and spaced from the web (11), and means (23) for producing a current of gas for entraining and carrying the fog through the application means (24), characterized in, that the web (11) coated is smoothened using a smoothening device.

8. An apparatus according to the claim 6 or 7, characterized in, that the web that is coated by a starch slurry fog is smoothened using a doctor blade (32), or two rollers placed on both sides of the web, e.g. in a surface sizing

unit.

9. An apparatus according to the claim 8, characterized in, that the web is smoothened using a doctor blade (32) or an air knife or an air brush.

10. An apparatus according to the claim 6, characterized in, that the nozzle for feeding the slurry or fog is provided with a slurry channel (26) for directing the slurry or fog, having an air channel or channels (25) placed adjacent to it or that there are many slurry channels (26) or only one slurry channel extending over the whole width of the web (11).

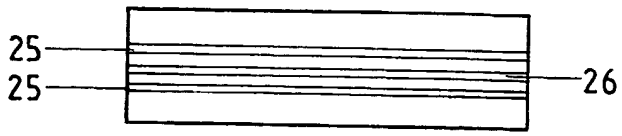


FIG. 5

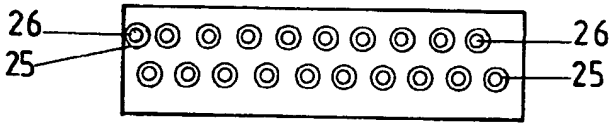


FIG. 4

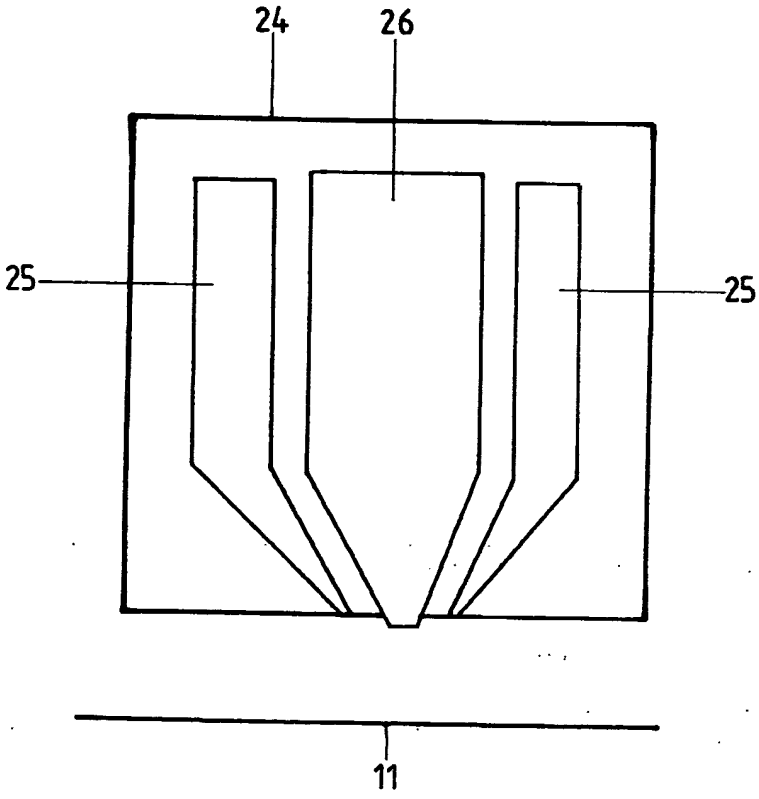


FIG. 1

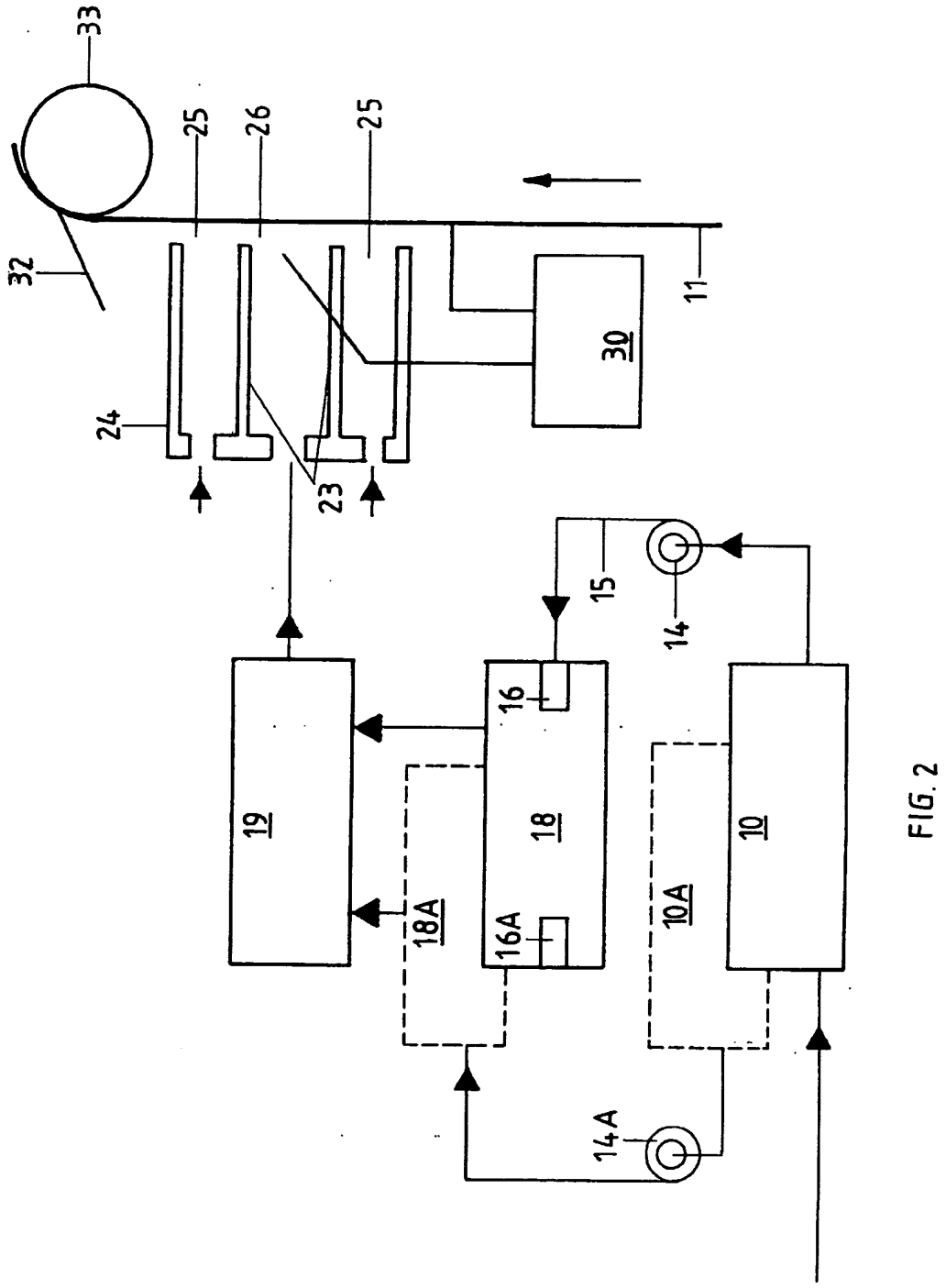


FIG. 2

FIG. 3a

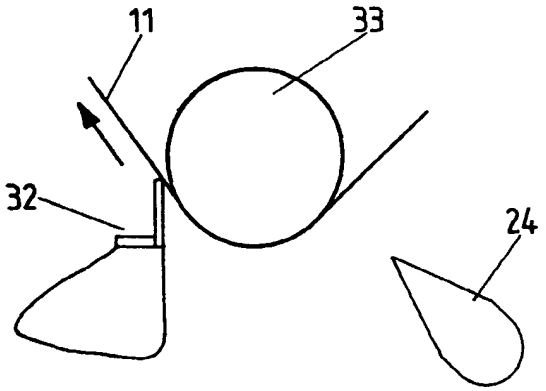
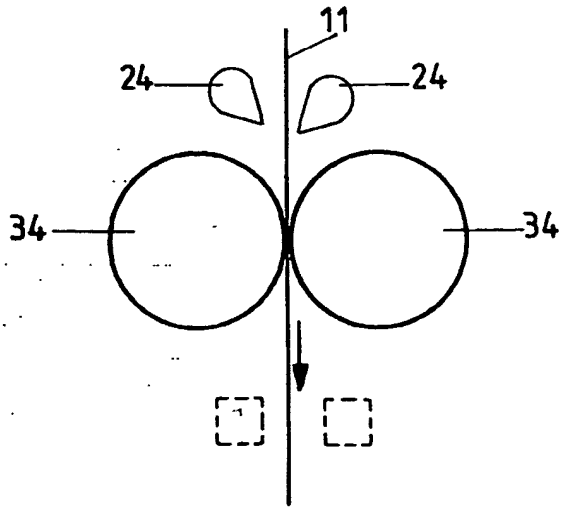


FIG. 3b



INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 93/00453

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B05C 11/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B05B, B05C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO, A1, 9003225 (SUNDHOLM, PATRICK ET AL), 5 April 1990 (05.04.90), page 1, line 1 - page 2, line 13, figure 1, claims 1,10-14	1,6,7
Y	EP, A1, 0060114 (DRG (UK) LIMITED), 15 Sept 1982 (15.09.82), page 7, line 6 - line 27, figure 1, claims 1,7	1,6,7
A	page 2, line 24 - line 32	2-4,9
A	GB, A, 1601282 (J.M. VOITH GMBH), 28 October 1981 (28.10.81), page 2, column 67 - line 97, figure 1	2

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"B" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 February 1994	09 -02- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Johan von Döbeln Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/12/93

International application No.
PCT/FI 93/00453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9003225	05/04/90	AU-A- 4313589	18/04/90
		EP-A- 0435904	10/07/91
EP-A1- 0060114	15/09/82	SE-T3- 0060114	
		EP-A- 0060113	15/09/82
GB-A- 1601282	28/10/81	AT-B- 360836	10/02/81
		BE-A- 866479	14/08/78
		CH-A- 627215	31/12/81
		DE-B,C- 2719204	17/08/78
		FR-A,B- 2388925	24/11/78
		JP-A- 53134915	25/11/78
		NL-A- 7804548	31/10/78
		SE-A- 7804750	30/10/78